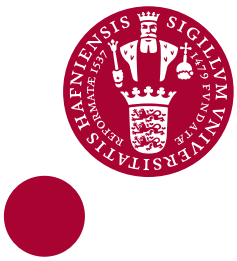

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First record of *Lagarodus* (Chondrichthyes: Euchondrocephali) from the Carboniferous of Svalbard, Arctic Norway

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The rather enigmatic genus *Lagarodus* is reported for the first time from the Bashkirian of Svalbard. *Lagarodus* first appeared in the equatorial region during the Tournaisian and then extended its geographical distribution to the intertropical zone around the Euramerican continent. The Svalbard discovery hints at the possibility that the northern species was different from the southern one.

Keywords: Lagarodus, Svalbard, Bashkirian, carbonate platform

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Introduction

This paper documents the first occurrence of Chondrichthyan fishes from the Mid Carboniferous of Spitsbergen, Arctic Norway. A single tooth belonging to the genus *Lagarodus* was found in the middle to late Bashkirian Trikolorfjellet Member of the Ebbadalen Formation. It adds to our knowledge of the geographic and stratigraphic distribution of *Lagarodus* which was hitherto known from the Moscow region in Russia, Ohio, Colorado, Arizona, Kansas and New Mexico in the US, North Greenland and Belgium (Stahl, 1999; Elliott et al., 2004; Hamm & Cicimurri, 2005), and confirms the connection from Spitsbergen and eastwards to the open marine platform areas of the Timan–Pechora Basin and Novaya Zemlya in Arctic Russia (e.g., Stemmerik, 2000). Its occurrence also indicates a temporary presence of fully marine conditions during Bashkirian rifting in Svalbard and the adjacent Norwegian Barents Sea.

Institutional abbreviations. NHMUK – Natural History Museum, London, NHMD–VP – Natural History Museum of Denmark, collection of vertebrate palaeontology.

Setting and stratigraphy

During Late Palaeozoic times Svalbard formed part of a huge E–W-oriented shelf along the northern margin of Pangea. It was located around 35°N during the Bashkirian (Golonka & Ford, 2000), and from the Bashkirian to Sakmarian deposition took place in a warm and arid climate (e.g., Johannessen & Steel, 1992; Beauchamp, 1994; Stemmerik, 2000).

The western part of the shelf was affected by rifting during the early Bashkirian and several NNW–SSE-

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oriented half-grabens started to form in the western Barents Sea and on Spitsbergen (Steel & Worsley, 1984). Initial deposition was non-marine, but the half-grabens were gradually transgressed during the Bashkirian and by Moscovian times most of the shelf formed a mosaic of open marine carbonate platforms (Larssen et al., 2005). The investigated specimen is from the uppermost carbonate bed in the Trikolorfjellet Member, Ebbadalen Formation, at western De Geerfjellet (N 78° 41'/E 16° 45'), central Spitsbergen (Fig. 1). The Trikolorfjellet Member forms an up to 200 m-thick unit of interbedded gypsum and carbonates with minor siliciclastics believed to reflect deposition in sabkha and marginal marine environments (Johannessen & Steel, 1992). The recorded specimen (Fig. 2) is from a 2 m-thick biogenic wackestone with more grain-rich layers dominated by crinoids and other echinoderms. The fauna also includes fragments of brachiopods, gastropods and bony fish. The bony fish are represented by two tooth morphotypes (Fig. 3), which cannot be identified beyond the actinopterygian level.

The upper Trikolorfjellet Member is of middle to late Bashkirian age based on the presence of a microbiota of fusulinid, endothyrid and archadiscid foraminifers in carbonate beds immediately below and above (Cutbill & Challinor, 1965; Mamet et al., 1993). It forms the upper part of the Bashkirian syn-rift succession in central Spitsbergen and is limited to the Billefjorden Trough (Fig. 1).

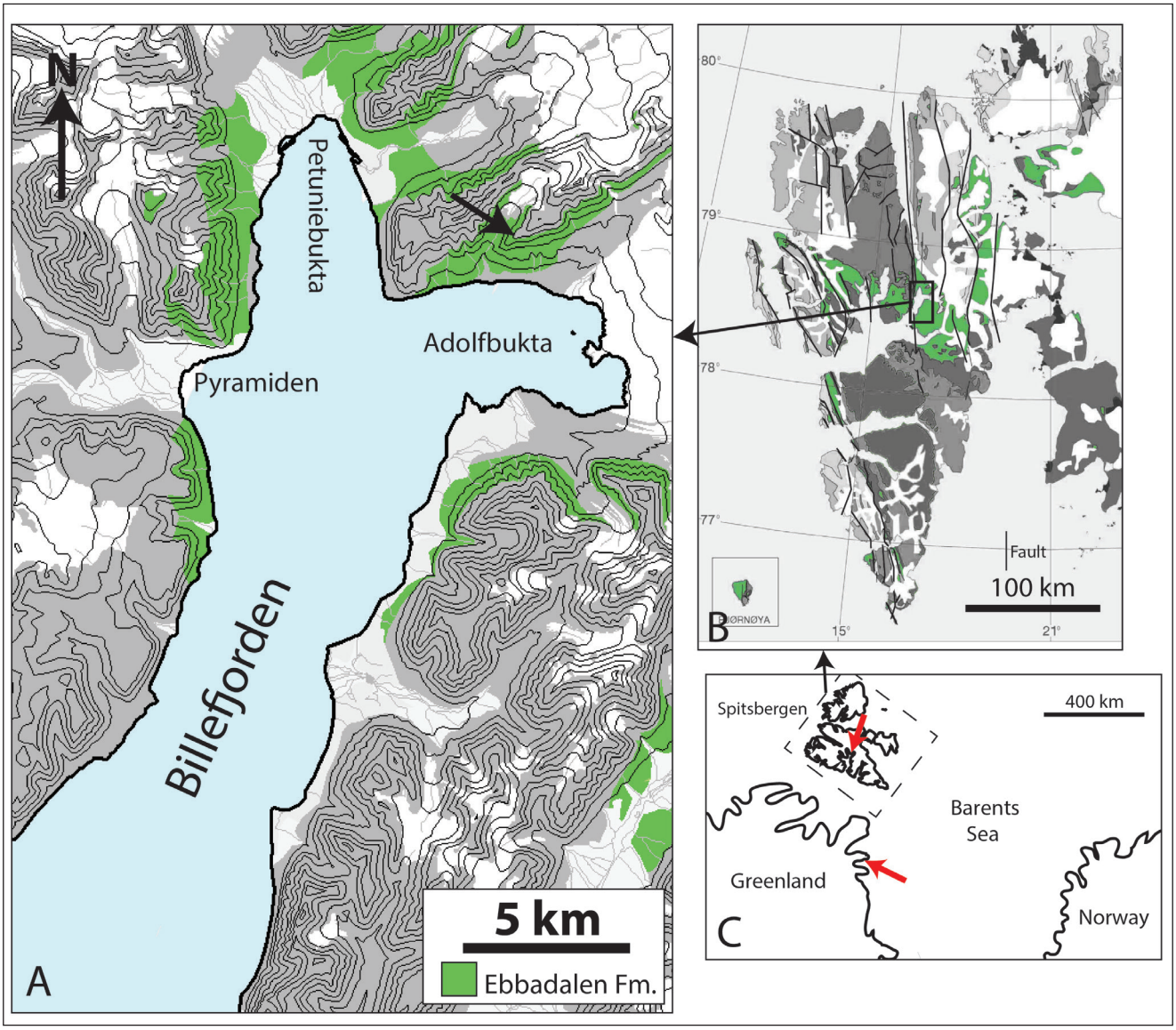

***Figure 1**. (A) Map of northern Billefjorden, central Spitsbergen, with outcrops of the Ebbadalen Formation highlighted in green. The arrow north of Adolfbukta is showing the location of the investigated material. (B) Distribution of outcrops of Upper Carboniferous–Permian sedimentary rocks in Svalbard. Major faults are indicated. (C) Pre-drift position of Spitsbergen, north of Greenland. The arrows show the locations of the Spitsbergen and Greenland specimens mentioned in the text.*

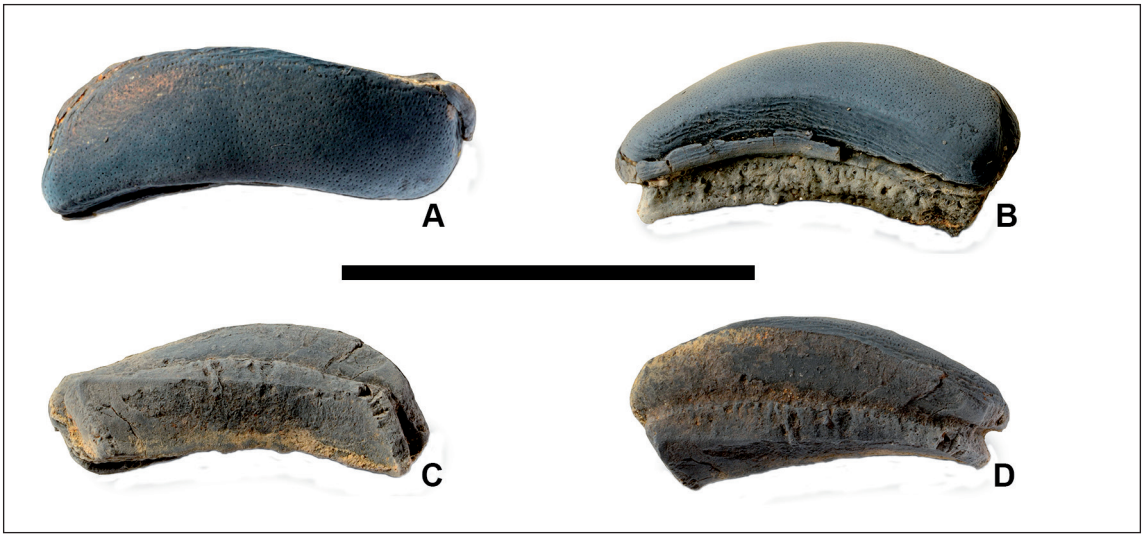

Figure 2. *Lateral tooth of Lagarodus sp. (NHMD–VP–9518) in (A) apical, (B) lingual, (C) basal and (D) labial views. Scale bar: 15 mm.*

Systematic Palaeontology

Class Chondrichthyes Huxley, 1880

Subclass Euchondrocephali Lund & Grogan, 1997

Order indet.

Family Lagarodontidae Lebedev, 2008
Genus *Lagarodus* Jaekel, 1898

Lagarodus sp.

NHMD–VP–9518 measures 18 mm mesio-distally, 6 mm labio-lingually and 7 mm apico-basally (Fig. 2). The crown is slightly twisted labio-lingually and S-shaped in apical view, the lingual side being mainly concave and the labial one mainly convex. Most of the enameloid cover has been worn off, and the apical surface of the crown shows a dense network of circular depressions corresponding to the openings of the dentinal canals of the tubular dentine (orthotrabeculine). Some concentric ridges are preserved on the mesial and distal extremities, as well as on part of the labial border, where the enameloid has been preserved. The lingual face of the crown is almost vertical and is ornamented by irregular, anastomosed ridges oriented mesio-distally. The labial face is inclined and overhangs the root. Its enameloid cover is not preserved. It is separated from the root by a constriction, which is also seen on the mesial and distal sides. It disappears on the lingual side.

The base is quadrangular and slightly twisted labio-lingually like the crown. Lingually, it is almost as thick as the crown, but labially the crown is thicker than the base. Its vascularisation is anaulacorhize, with small foramina scattered over the labial, lingual, mesial and distal faces. On the mesial side, the base forms an angle with the crown, whereas on the distal one, it is in continuation with the crown.

Discussion

The crown is made of orthotrabeculine and the thick enameloid cover of at least its mesial and lingual sides are characters typical of the family Lagarodontidae (Lebedev, 2008). This family is exclusively known from isolated teeth and its phylogenetic relationships among enchondrocephals are poorly understood. It is currently monogeneric and monospecific (Lebedev, 2008). The twisted shape of NHMD–VP–9518 matches that of the lateral teeth of *Lagarodus specularis* from the Moscovian–Kasimovian of Russia, a senior synonym of *Lagarodus angustus* (Lebedev, 2008), although the teeth of the latter species possess straighter labial and lingual margins of the crown than NHMD–VP–9518 (Hansen, 1986; Zidek & Kietzke, 1993; Elliott et al., 2004; Hamm & Cicimurri, 2005; Lebedev, 2008). It suggests that NHMD–VP–9518 belongs to a different species, but a single lateral tooth does not represent sufficient material to erect a new species. The tooth described from the upper Moscovian *Wedekindellina* zone of Greenland as *Lagarodus* sp. (Bendix-Almgreen, 1975) is an incomplete parasymphysial one, such that a meaningful comparison with NHMD–VP–9518 is not possible.

NHMD–VP–9518 shares with NHMUK P63892 a rather elongated shape mesio-distally, a labio-lingually twisted crown and a similar ornamentation of the non-occlusal parts of the crown (Stahl, 1999, fig. 86H). The provenance of NHMUK P63892 was given by Stahl (1999) as: Lower Carboniferous, British Isles. However, a check

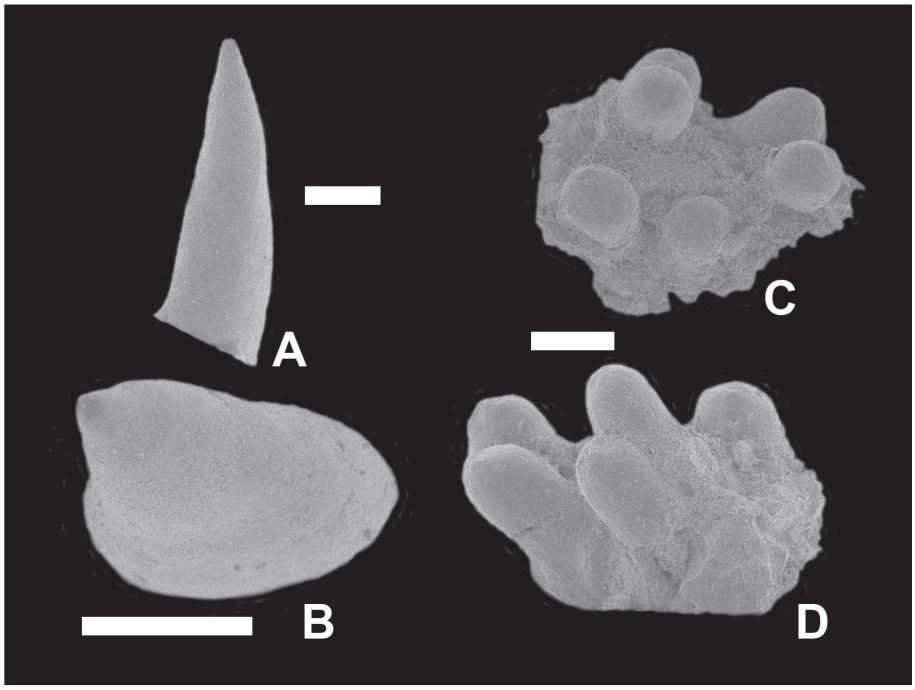

Figure 3. *Actinopterygian tooth morphotypes. (A–B) Morphotype A (NHMD–VP–9519) in (A) lateral and (B) apical views. (C–D) Bone fragment bearing six teeth of morphotype B (NHMD–VP–9520) in (C) apical and (D) lateral views. Scale bars: 100 µm*

in the original register at the Natural History Museum, London gives: *?Psammodus* sp. from the Moscovian of Mjatschkova, Russia (M. Richter, pers. comm., 2014). As the Myachkovo quarry is the locality where the neotype of *Lagarodus specularis* comes from (Lebedev, 2008), it is likely that NHMUK P63892 in fact represents a lateral (*specularis* morphotype) tooth of *Lagarodus*.

The investigated material is older than the mid-continent faunas of the US which are of late Atokan – Desmoinesian age and older than the Greenland fauna described by Bendix-Almgreen (1975) since later biostratigraphic work has shown that the Greenland fauna is of Moscovian age (Davydov et al., 2001). As the record of *Lagarodus* in the Lower Carboniferous of Russia now appears doubtful (Lebedev, 2008), the oldest record of this genus is from the Tournaisian of Belgium (De Koninck, 1878; Hansen, 1986), which would anyway suggest that this genus appeared in the equatorial region. However, De Koninck (1878) provided a rather crude description and illustration of the Belgian tooth so that its precise phylogenetic affinities are quite difficult to decipher. Its convex labial margin in apical view is quite similar to that of NHMD–VP–9518, but its lingual margin is much straighter. The Belgian tooth appears also quite unusual as it seems that there are well-developed nodes at the base of the lingual face (De Koninck, 1878, fig. 6b). Anyway, the species *L. specularis* is thereafter known from the equatorial region in Russia during the Moscovian and Kasimovian (Lebedev, 2008) and in the southern tropical region in North America during the Moscovian (Elliott et al., 2004; Hamm & Cicimurri, 2005). Its record in the northern tropical region in the Bashkirian of Svalbard and the Moscovian of Greenland (Bendix-Almgreen, 1975) is still patchy, but the tooth described here from Svalbard might suggest that the northern species was different from the southern one.

Conclusion

The discovery of *Lagarodus* in Svalbard adds to its range and distribution. It was restricted to the coast of the Euroamerican continent and the vast majority of the finds are in mid-latitude areas with warm and arid climate. Data concerning *Lagarodus* are still patchy, but they suggest that the genus appeared in the equatorial region during the Tournaisian and then extended its geographical distribution to the intertropical zone around the Euramerican continent. The Svalbard discovery hints at the possibility that the northern species was different from the southern one.

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